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NATURE OF THE BETA-PHASE OF NICKEL - ALUMINUM SYSTEM

by

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А а	*А а*	A, a	Р р	*Р р*	R, r
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В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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NATURE OF THE BETA-PHASE OF NICKEL - ALUMINUM SYSTEM

L. N. Guseva

(Presented by Academician G. G. Urazov on 31 Jan. 1951)

During the detailed study of system nickel - aluminum in the field of β-phase with X-ray method (1) it was established that at room temperature the β-phase preserves uniformity from 45.25 to 60 at.% Ni. Later than (2) during the determination of the boundary o β-phase from the nickel side were obtained the same results.

Data with respect to a change in lattice constant and density of alloys with composition change allowed Bradley and Taylor to establish that the solid solutions in the region of the uniformity of β-phase have uncommon structure. Alloys with 50 at.% Ni have the body-centered cubic structure of the type CsCl with a regulated atomic arrangement. With an increase in the content of nickel are formed solid solutions by the statistical substitution of aluminum atoms in crystal lattice by nickel atoms. The substitution however, of nickel atoms by aluminum atoms is observed only to 51 at.% Al; with further increase in the content of aluminum solid solutions have defective structure, since part of the positions in the lattice, occupied earlier by nickel, remains free. This leads to the change of the number of atoms in the unit cell, which on the boundary of phase reaches value of 1.84.

In the literature accessible to us there is no information about the nature of change in the physical properties of β-phase with composition change. These in insufficient known data for explaining the nature of this phase. Frequently without sufficient bases they classify it as daltonide type phases (3).

As initial materials for the preparation of alloys we used 99.99% aluminum and electrolytic nickel. Melting of samples was produced in high-frequency furnace in the corundum crucibles in flux from the mixture of calcium fluoride (1378°) and sodium fluoride (992°). The process of the formation of compounds NiAl continues with the large heat liberation; therefore furnace was turned off at the melting point of charge, then, after the end of reaction, it was switched on again, alloy was melted and was sucked into the porcelain small tubes of approximately 3 mm in diameter. The length of rods was different - from 15 to 25 cm. For the measurements the electrical conductivity were used rods, which do not have surface defects.

The obtained samples were subjected to homogenization annealing at a temperature of 1100° for 4 days in vacuum, after which they were cooled with the furnace.

The measurement of electrical resistance was conducted with the aid of the potentiometer, at temperatures of 25 and 100°.

The results of measurements and calculation are given in Table 2 and Fig. 1b and c.

After measurement of electrical conductivity rods were destroyed (in this case attention was paid to the presence of voids) and they underwent X-ray and chemical analyses. The latter was carried out by precipitating nickel with alcohol solution/opening of dimethylglyoxime in the alkaline medium. Significant loss in burning of charge in this case was not observed.

In Table 1 is given the composition of some alloys by the charge and according to the analysis.

Table 1

(1) Ni, вес. % по шихте	62	64	66	70	72	77
(2) Ni, вес. % по анализу	62,43	64,76	65,38	69,78	72,2	77,2

Key: (1). ... weight ... by charge. (2). ... weight ... according to analysis

The results of parallel determinations for two alloys, nearest to compound NiAl, proved to be (in wt.% Ni): 1) 68.5; 68.8; 69.17; 69.26; 69.12 (average. 69.0); 2) 67.87; 68.32; 67.83; 67.72 (media. 67.9).

All alloys underwent analysis [1].

X-ray analysis was conducted for determining the region of the uniformity of beta-phase. X-ray photographs were obtained according to Debye's method (layer was embedded according to the method of Straumanisa) during the cobalt emission. The lattice constant of alloys was calculated by doublet (310) $\alpha_1\alpha_2$. Powders for the survey were prepared in the mortar and for relief of the work hardening were annealed at 600° in the vacuum during 30 min. In this case the distinct splitting of doublet was observed. The data of the measurements of the parameters of alloys are given in Table 2 and Fig. 1a.

[1] Chemical analysis was performed by Z. V. Popovoy.

The comparison of the results of measuring the parameters in the region of β-phase with the data of Bradley and Taylor (1) makes it possible to leave the boundaries of phase without changes, since they roughly will agree. In this case also is observed the shift of the maximum of curve from the ordinate of compound NiAl in the direction of a larger content of aluminum.

The form of the curves of change in the electrical resistance and its temperature coefficient with the composition is found in direct dependence on the nature of the structure of alloys. Electrical resistance increases in proportion to the dissolution in NiAl of both aluminum and nickel. However, its minimum value is observed not with 50 at.% Ni, when compound reaches its maximum ordering, but with a somewhat smaller content of nickel.

Respectively changes with the composition also the thermal coefficient of electrical resistance. Thus, in the curves composition - property is absent the singular point, which corresponds to the ordinate of compound NiAl.

Properties in the region of the solid solution of nickel in NiAl change in accordance with a change in the ordering of alloys - with an increase in the ordering ρ decreases, but α increases. However, an increase in the electrical resistance and a decrease of its temperature coefficient during the dissolution of aluminum in NiAl is connected with the advent of in these alloys of defective structure.

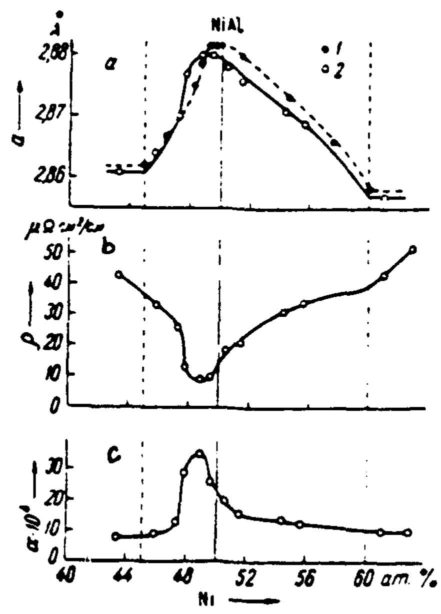

Fig. 1. 1 - Bradley and Taylor, 2 - present investigation

Table 2

(a) Ni, в ат. %	(a) ρ в μΩ см²/см	α	(a) a в Å	(b) Фазы
43,3	42,7	0,0008	2,861	NiAl + Ni_2Al_3
45,8	33,5	0,0009	2,864	NiAl
47,3	25,5	0,0013	2,870	NiAl
47,7	13,1	0,0029	2,877	NiAl
48,7	9,5	0,0035	2,880	NiAl
49,4	10,0	0,0026	2,880	NiAl
50,5	19,0	0,0020	2,878	NiAl
51,5	21,0	0,0016	2,876	NiAl
54,4	30,8	0,0014	2,871	NiAl
55,7	34,0	0,0013	2,869	NiAl
60,9	43,0	0,0010	2,857	NiAl + Ni_3Al
62,7	51,5	0,0010	—	NiAl + Ni_3Al

Key: (a). ... in ... (b). Phases

I. Isaychev and V. Miretskiy (4) studied by X-ray method the behavior of the alloys of beta-phase at high temperatures for the purpose of the explanation of the nature of ordering change with an increase in the temperature. The authors qualitatively showed that the alloy, which contains 50 atm. % Ni, at a temperature of 600° undergoes partial disordering. On the basis of the approximation calculation of the X-ray photographs, obtained at high temperatures, was established the presence of two centered cubic lattices with different constants (difference between the constants was 0.04Å), in this case more intensive reflections gave the phase with the larger constant, which revealed also the presence of reflections with the odd sum of indices. Obtained experimental data made it possible to consider the disordering of β-phase as two-phase decomposition. However, the authors focus attention on the possibility of large errors during the determination of the absolute values of constants both of lattices.

Having use of considerably more advanced equipment for the survey at high temperatures, we were able to approach this question from the quantitative side. For the study were selected two alloys with 49.4 and 50.5 at.% Ni. X-ray photographs were obtained in the chamber/camera for the survey at high temperatures according to Debye's method of design of the Institute of General and Inorganic Chemistry of the AS USSR. Sample in the form of powder, soldered into the quartz capillary, evenly revolved during the exposure, the hollow cassette of chamber was continuously cooled by running water. Survey was produced from the samples at room temperature, 600 and 900°. Fig. 2 shows the X-ray photographs of alloy with 49.4 at.% Ni, obtained at room temperature and 900°. Lines in the X-ray photographs are sharp, weak reflections from the planes with the odd sum of indices are also visible distinctly (see insert to p. 440).

In all X-ray photographs is established the presence of a regulated cubic structure of the type CsCl; in this case it was impossible to detect not even one line, which does not correspond to this structure. Only the normal shift of lines, connected with a change in lattice parameter at an increase in the temperature of sample, was observed.

The X-ray photographs, obtained from one and the same sample at 20 and 900° were scanned photometrically.

Intensity measurement of lines (100) and (110) showed that the ordering with an increase in the temperature does not change.

Is observed somewhat smaller lattice constant in alloy with 49.4 at.% Ni in the hardened state, equal to 2.878Å while in the annealed state it reaches 2.880Å. This change still does not exceed the accuracy of determination and, apparently it can be connected with the earlier appearance of lattice defects at high temperatures.

In conclusion I thank associate member of the AS USSR N. V. Ageyev for his interest and valuable comments on the work.

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